January 2002

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Physics 30

Grade 12 Diploma Examination

Alberta
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January 2002

Physics 30

Grade 12 Diploma Examination

Description

Time: This examination was developed to be completed in 2.5 h; however, you may take an additional 0.5 h to complete the examination.

This is a **closed-book** examination consisting of

- 37 multiple-choice and 12 numerical-response questions, of equal value, worth 70% of the examination
- 2 written-response questions, of equal value, worth a total of 30% of the examination

This examination contains sets of related questions. A set of questions may contain multiple-choice and/or numerical-response questions.

Tear-out data sheets are included near the back of this booklet. A Periodic Table of the Elements is also provided.

Note:** The perforated pages at the back of this booklet may be torn out and used for your rough work.* ***No marks *will be given for work done on the tear-out pages.*

Instructions

- You are expected to provide your own calculator. You may use any scientific calculator or a graphing calculator approved by Alberta Learning.
- You are expected to have cleared your calculator of all information that is stored in the programmable or parametric memory.
- Use only an HB pencil for the machine-scored answer sheet.
- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- Read each question carefully.
- Consider all numbers used in the examination to be the result of a measurement or observation.
- When performing calculations, use the values of constants provided on the tear-out sheets.
- If you wish to change an answer, erase **all** traces of your first answer.
- Do not fold the answer sheet.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Learning.
- Now turn this page and read the detailed instructions for answering machine-scored and written-response questions.

Multiple Choice

- Decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

Example

This examination is for the subject of

A. science
B. physics
C. biology
D. chemistry

Answer Sheet

Ⓐ ● Ⓒ Ⓓ

Numerical Response

- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- If an answer is a value between 0 and 1 (e.g., 0.25), then be sure to record the 0 before the decimal place.
- **Enter the first digit of your answer in the left-hand box. Any boxes on the right that are not needed are to remain blank.**

Examples

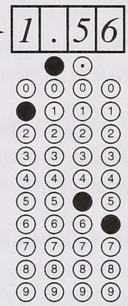
Calculation Question and Solution

If a 121 N force is applied to a 77.7 kg mass at rest on a frictionless surface, the acceleration of the mass will be ________ m/s^2.
(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

$$a = \frac{F}{m}$$

$$a = \frac{121\text{ N}}{77.7\text{ kg}} = 1.557\text{ m/s}^2$$

Record 1.56 on the answer sheet ⟶



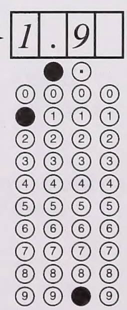
Calculation Question and Solution

A microwave of wavelength 16 cm has a frequency, expressed in scientific notation, of $b \times 10^w$ Hz. The value of b is ________ .
(Record your **two-digit answer** in the numerical-response section on the answer sheet.)

$$f = \frac{c}{\lambda}$$

$$f = \frac{3.00 \times 10^8\text{ m/s}}{0.16\text{ m}} = 1.875 \times 10^9\text{ Hz}$$

Record 1.9 on the answer sheet ⟶



Correct-Order Question and Solution

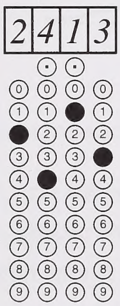
When the following subjects are arranged in alphabetical order, the order is ____, ____, ____, and ____ .

1 physics
2 biology
3 science
4 chemistry

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Answer: 2413

Record 2413 on the answer sheet ⟶



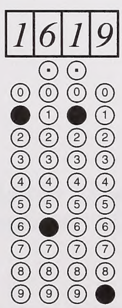
Scientific Notation Question and Solution

The charge on an electron is $-\boldsymbol{a}.\boldsymbol{b} \times 10^{-cd}$ C. The values of $\boldsymbol{a}$, $\boldsymbol{b}$, $\boldsymbol{c}$, and $\boldsymbol{d}$ are ____, ____, ____, and ____ .

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Answer: $q = -1.6 \times 10^{-19}$ C

Record 1619 on the answer sheet ⟶

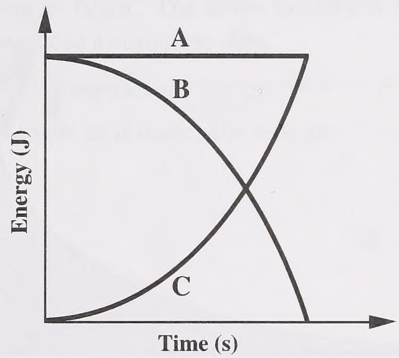


Written Response

- Write your responses in the examination booklet as neatly as possible.
- For full marks, your responses must address **all** aspects of the question.
- Descriptions and/or explanations of concepts must include pertinent ideas, diagrams, calculations, and formulas.
- Your responses must be presented in a well-organized manner using complete sentences, correct units and correct significant digits, where appropriate.
- Relevant scientific, technological, and/or societal concepts and examples must be identified and made explicit.

Use the following information to answer the first question.

The gravitational potential energy, kinetic energy, and mechanical energy of a bungee jumper during the free-fall portion of a jump are graphed below.



1. Lines A, B, and C represent, respectively,

   A. mechanical energy, gravitational potential energy, and kinetic energy
   B. mechanical energy, kinetic energy, and gravitational potential energy
   C. gravitational potential energy, mechanical energy, and kinetic energy
   D. kinetic energy, gravitational potential energy, and mechanical energy

---

2. A truck with a mass of 4.00×10^4 kg is travelling at 100.0 km/h. If the driver reduces the truck's speed to 60.0 km/h, then the truck's kinetic energy has changed by

   A. -2.22×10^4 J
   B. -9.88×10^6 J
   C. -3.20×10^7 J
   D. -1.28×10^8 J

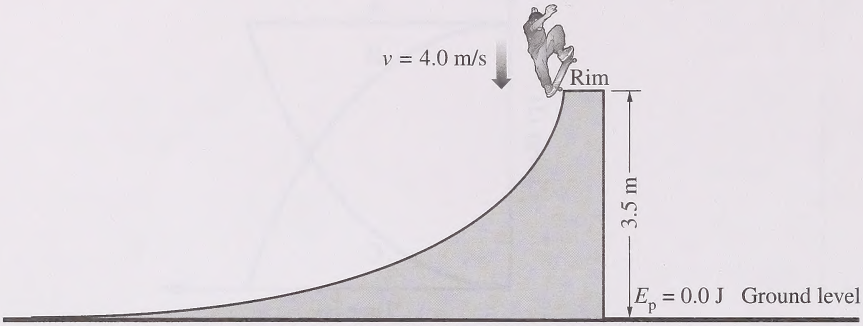
Numerical Response

1. A pump delivers 56.0 L/min of water from a well that is 20.0 m deep. A 1.00 L volume of water has a mass of 1.00 kg. The work done by the pump in 1.00 s is __________ J.

(Record your **three-digit** answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

After performing a trick above the rim of a skateboard ramp, a 56 kg skateboarder lands on the ramp 3.5 m above ground level with a downward velocity of 4.0 m/s.



Friction in the wheels of the skateboard and air resistance cause a loss of 9.0×10^2 J of mechanical energy.

3. The skateboarder's speed at the bottom of the ramp will be

A. 6.0 m/s
B. 7.2 m/s
C. 9.2 m/s
D. 11 m/s

---

4. A spring is compressed a distance of x. When the spring is released, it shoots a marble of mass m vertically upward from ground level. The maximum height reached by the marble is h. The magnitude of the marble's momentum at the highest point of the marble's trajectory is equivalent to

A. 0
B. mgh
C. $m\sqrt{2gh}$
D. $x\sqrt{2gh}$

Use the following information to answer the next two questions.

> During an archery competition, an arrow of mass 35.0 g is fired horizontally with a speed of 1.10×10^2 m/s at a target fixed to a wall. The arrow does not drop significantly during its flight. The arrow penetrates the target to a depth of 5.00 cm and is brought to a complete stop.

5. The kinetic energy of the arrow as it leaves the bow is

A. 4.24×10^5 J
B. 2.12×10^5 J
C. 4.24×10^2 J
D. 2.12×10^2 J

Numerical Response

2. The magnitude of the average force exerted by the target on the arrow, expressed in scientific notation, is $a.bc \times 10^d$ N. The values of a, b, c, and d are _____, _____, _____, and _____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

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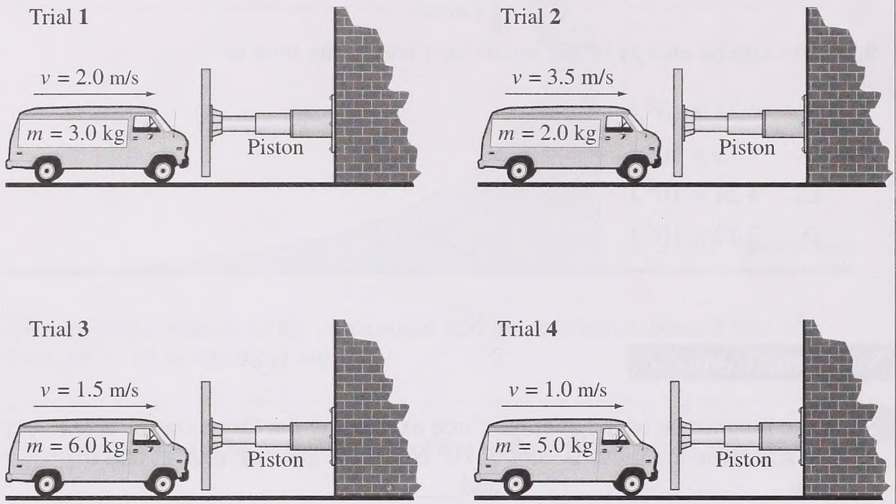
6. A 75.0 kg hockey player moving at +10.0 m/s crashes into a second, stationary hockey player. After the collision, the two skaters move as a unit at +4.50 m/s. In the collision, the impulse received by the second hockey player was

A. $+1.09 \times 10^3$ kg·m/s
B. $+7.50 \times 10^2$ kg·m/s
C. $+4.13 \times 10^2$ kg·m/s
D. $+3.38 \times 10^2$ kg·m/s

Use the following information to answer the next question.

A student performs an experiment to investigate the time required to stop a toy van. In each of four trials, the student varies the speed and mass of the van. The toy van is brought to rest by a piston that applies a uniform force that is the same for each trial.



Numerical Response

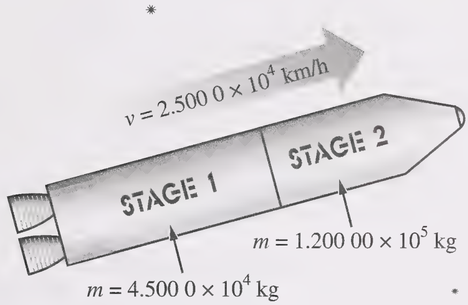
3. When the trials above are listed in order from the trial that has the longest stopping time to the trial that has the shortest stopping time, the order is

__________, __________, __________, and __________.
longest **shortest**

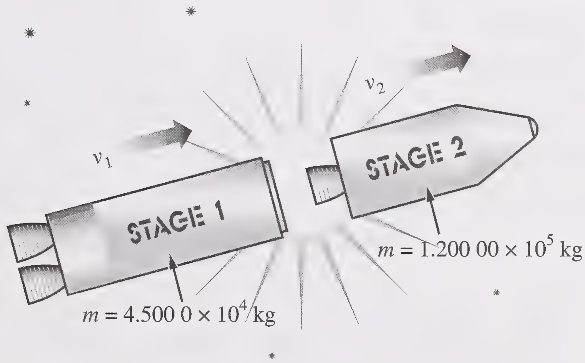
(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next question.

A particular rocket consists of stage 1 ($m = 4.500\,0 \times 10^4$ kg) and stage 2 ($m = 1.200\,00 \times 10^5$ kg). Initially, the stages move together at $2.500\,0 \times 10^4$ km/h.



Later, a small explosion causes the stages to separate.



After separation, stage 1 moves $3.000\,0 \times 10^1$ km/h slower than it did before separation.

7. The speed, v_2, of stage 2 immediately after separation is

A. 24 920 km/h

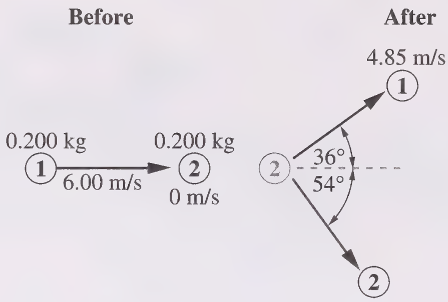
B. 24 989 km/h

C. 25 011 km/h

D. 25 080 km/h

Use the following information to answer the next question.

Two identical metal pucks were made to collide on a frictionless surface. Before the collision, puck 1 was moving at 6.00 m/s and puck 2 was stationary. After the collision, the pucks moved as shown in the diagram below.



8. The magnitude of the **momentum** of puck 2 after the collision was

A. 1.33 kg·m/s
B. 0.970 kg·m/s
C. 0.705 kg·m/s
D. 0.570 kg·m/s

---

9. A conducting sphere X that has an initial charge of $+2.0 \times 10^{-8}$ C and an identical conducting sphere Y that has an initial charge of -3.0×10^{-8} C are touched together. After they are separated, the charge on sphere X is

A. -5.0×10^{-9} C
B. -1.0×10^{-8} C
C. -2.5×10^{-8} C
D. -5.0×10^{-8} C

10. The magnitude of the electrical force on an alpha particle that is 4.0×10^{-10} m from an electron is

A. 5.8×10^{-19} N

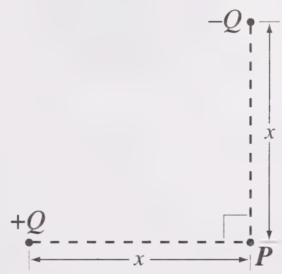
B. 1.2×10^{-18} N

C. 1.5×10^{-9} N

D. 2.9×10^{-9} N

Use the following information to answer the next question.

Two point charges of equal magnitude, $+Q$ and $-Q$, are each placed at an equal distance, x, from point P, as shown below.



11. The direction of the resultant electric field at point P is

A.

B.

C.

D.

12. A unit combination that is equivalent to the joule is

A. W·s

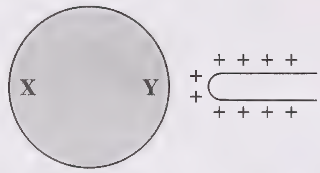
B. N/m

C. kg·m/s^2

D. kg·m/s

Use the following information to answer the next question.

A positively charged rod is placed near, but not touching, a neutral metal ball.



13. As a result of the rod's position, side X of the ball becomes relatively

A. negative and the ball is repelled from the rod

B. positive and the ball is repelled from the rod

C. negative and the ball is attracted to the rod

D. positive and the ball is attracted to the rod

14. Which of the following statements describes a relationship between the forces described by Coulomb's Law and the forces described by Newton's Law of Universal Gravitation?

A. In atoms, gravitational forces are weaker than electrical forces.

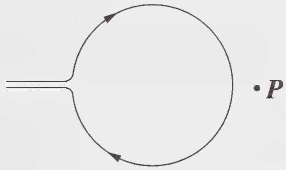
B. Gravitational forces and electrical forces are attractive forces only.

C. Gravitational forces act at any distance; whereas, electrical forces act at very short distances only.

D. As the distance between objects increases, electrical forces increase, whereas gravitational forces decrease.

Use the following diagram to answer the next question.

Electron Flow in a Wire Loop



15. In an apparatus such as the one shown above, the direction of the magnetic field at point ***P*** due to the electron flow would be

A. into the page

B. out of the page

C. toward the left side of the page

D. toward the right side of the page

Use the following information to answer the next question.

A long, straight wire carries a current of 2.00 A. The magnetic field strength around the current-carrying wire can be calculated using the equation

$$B = \frac{k'I}{r}$$

where k' = 2.00×10^{-7} T·m/A
B = magnetic field strength (T)
I = current in the wire (A)
r = distance from the centre of the wire (m)

Numerical Response

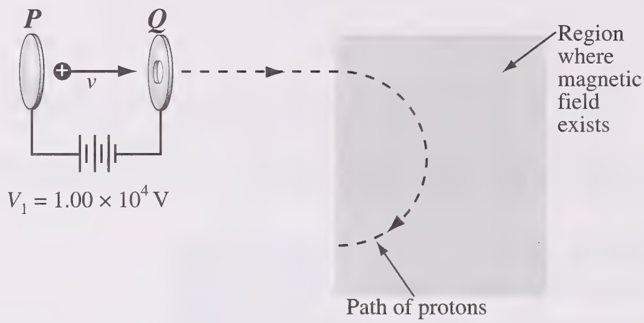
4. The magnetic field strength 15.0 cm from the centre of the wire, expressed in scientific notation, is $\boldsymbol{a.bc} \times 10^{-\boldsymbol{d}}$ T. The values of ***a***, ***b***, ***c***, and ***d*** are _____ , _____ , _____ , and _____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

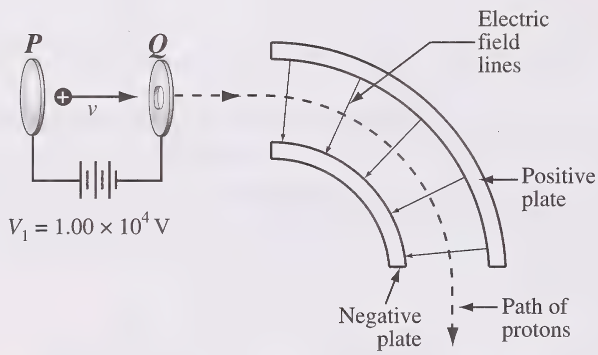
Use the following information to answer the next six questions.

A mass spectrometer uses either a magnetic field or an electric field to deflect charged particles.

Magnetic Field Mass Spectrometer



Electric Field Mass Spectrometer



16. In the magnetic field mass spectrometer shown above, the direction of the magnetic field is

A. into the page

B. out of the page

C. toward the left side of the page

D. toward the right side of the page

17. The energy gained by a proton as it moves from plate ***P*** to plate ***Q*** is

A. 1.00×10^4 eV

B. 1.00×10^4 J

C. 1.00×10^4 V

D. 1.00×10^4 N

18. A proton starts from rest at plate ***P***. The speed of the proton as it passes through the hole in plate ***Q*** is

A. 6.92×10^5 m/s

B. 1.38×10^6 m/s

C. 2.96×10^7 m/s

D. 5.93×10^7 m/s

Use your recorded answer from ***Multiple Choice 18*** *to answer* ***Numerical Response 5.****

Numerical Response

5. In the magnetic field mass spectrometer shown, the radius of curvature of a proton's path is 3.00 m. The magnetic field intensity, expressed in scientific notation, is $\boldsymbol{a.bc} \times 10^{-\boldsymbol{d}}$ T. The values of ***a***, ***b***, ***c***, and ***d***, are _____ , _____ , _____ , and _____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

***You can receive marks for this question even if the previous question was answered incorrectly.**

*Use your recorded answer from **Multiple Choice 18** to answer **Numerical Response 6**.**

Numerical Response

6. In the electric field mass spectrometer shown, the radius of curvature of a proton's path is 10.0 m. The proton experiences an electrostatic force, expressed in scientific notation, of $b \times 10^{-w}$ N. The value of b is ____________.

(Record your **three-digit** answer in the numerical-response section on the answer sheet.)
***You can receive marks for this question even if multiple-choice question 18 was answered incorrectly.**

Use the following additional information to answer the next question.

A different electric field mass spectrometer is set up so that an electron would follow the same curved path that the proton travelled. In this mass spectrometer, plate ***P*** is __*i*__, plate ***Q*** is __*ii*__ , and the electric field direction between the curved parallel plates is __*iii*__ .

19. The row that correctly completes the statement above is row

Row	*i*	*ii*	*iii*
A.	positive	negative	unchanged
B.	positive	negative	reversed
C.	negative	positive	unchanged
D.	negative	positive	reversed

20. Charged particles moving toward Earth are trapped within a field near Earth, where they cause the aurora borealis (northern lights) and aurora australis (southern lights). The field in which the particles are trapped is

A. a gravitational field

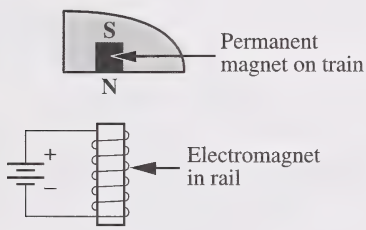
B. an induction field

C. a magnetic field

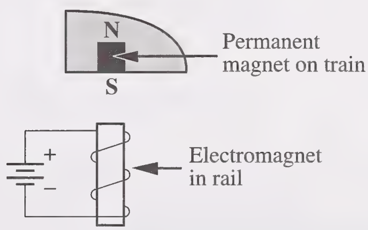
D. an electric field

21. Magnetic levitation (maglev) trains "float" above the rails. A permanent magnet mounted on the train interacts with an electromagnet in the rail. If it is assumed that the permanent magnet in each of the diagrams below is identical and that the current is the same in each electromagnet, then which of the following designs would produce the **greatest** lift?

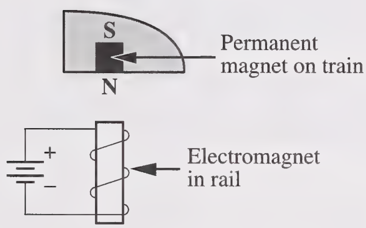
A.



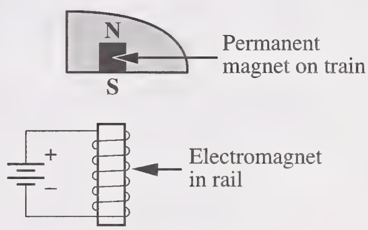
B.



C.



D.



Use the following information to answer the next two questions.

A planetary space probe can measure the magnetic field intensity near the surface of a planet by trailing a long wire perpendicular to the planet's magnetic field lines.

A space probe orbiting Jupiter travels at a speed of 2.94 km/s relative to the planet's magnetic field and trails a wire 30.0 m long that passes across the planet's magnetic field. The magnetic field intensity around Jupiter varies from about 0.300 mT at the equator to about 1.40 mT at the poles.

22. The potential difference, in millivolts, induced in the space probe's wire when the space probe orbits over Jupiter's equator is

A. 2.65×10^{1} mV

B. 1.23×10^{2} mV

C. 2.65×10^{4} mV

D. 1.23×10^{5} mV

Use your recorded answer from ***Multiple Choice 22*** *to answer* ***Numerical Response 7.****

Numerical Response

7. The electric circuit connected to the space probe's wire has a high resistance. When the current in the circuit is 1.42×10^{-4} A, the resistance of the circuit, expressed in scientific notation, is $\boldsymbol{b} \times 10^{\boldsymbol{w}}$ Ω. The value of $\boldsymbol{b}$ is ________.

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

***You can receive marks for this question even if the previous question was answered incorrectly.**

Use the following information to answer the next two questions.

> An AC welding device contains a transformer that operates on an input 220 V AC circuit operating at 30.0 A. The output current is 180 A. The output voltage fluctuates during the welding process. The input and output voltages are measured by AC voltmeters on the welding device.

23. In this welding device, the ratio of primary turns to secondary turns in the transformer is approximately

A. 6 : 1
B. 1 : 6
C. 7.3 : 1
D. 1 : 7.3

Numerical Response

8. The reading on the voltmeter that measures the output voltage will be ________V.

(Record your **three-digit** answer in the numerical-response section on the answer sheet.)

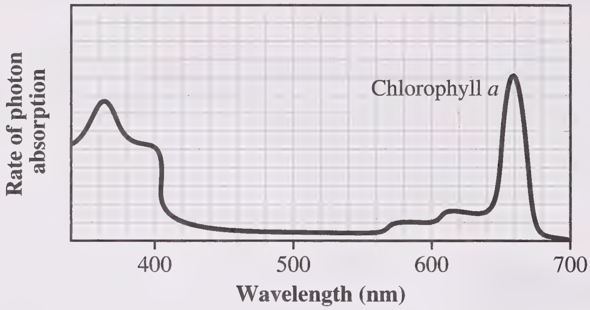
24. Electromagnetic radiation is always produced as a result of the

A. acceleration of electric charges
B. movement of electric charges
C. acceleration of masses
D. magnetic fields

Use the following information to answer the next question.

Chlorophyll in plants absorbs photons of electromagnetic radiation and converts them into chemical potential energy. Chlorophyll *a* is one of the main types of chlorophyll. The graph below shows the relationship between the absorption of photons by chlorophyll *a* and the wavelength of the photons striking the plants.

Absorption Rate as a Function of Incident Wavelength



25. To produce the maximum rate of photon absorption by chlorophyll *a*, photons should have an energy of

A. 1.77 eV
B. 1.88 eV
C. 2.48 eV
D. 3.40 eV

---

26. Compared with the wavelength and frequency of visible light, the electromagnetic waves emitted during nuclear fission have

A. longer wavelengths but a lower frequency
B. longer wavelengths and a higher frequency
C. shorter wavelengths and a lower frequency
D. shorter wavelengths but a higher frequency

27. An electromagnetic wave travels vertically upward, perpendicular to Earth's surface. If the magnetic field component of the wave oscillates in a north-south direction, then the electric field component will oscillate in

A. an east-west direction

B. a north-south direction

C. a vertically upward direction

D. a vertically downward direction

28. Which of the following properties is a property of X-rays but not of radio waves?

A. Reflection

B. Refraction

C. Interference

D. Gas ionization

29. If the charge-to-mass ratio of an ion with a $3+$ charge is 1.4×10^{7} C/kg, then the mass of the ion is

A. 1.1×10^{-26} kg

B. 3.4×10^{-26} kg

C. 1.0×10^{-25} kg

D. 6.7×10^{-12} kg

Use the following information to answer the next three questions.

X-rays were discovered in 1895 by Roentgen. In the cathode ray tube that he used, a high electrical potential difference between the anode and the cathode accelerated the electrons. The electrons then collided with a copper target.

Three Types of Energy

1 electrical potential energy
2 electromagnetic energy
3 kinetic energy

Numerical Response

9. In the production of X-rays, the three types of energy listed above occur in order from _____ to _____ to _____.

(Record all **three digits** of your answer in the numerical-response section on the answer sheet.)

Numerical Response

10. The minimum accelerating voltage necessary to produce an X-ray with a wavelength of 6.25×10^{-11} m, expressed in scientific notation, is $\boldsymbol{a.bc} \times 10^{\boldsymbol{d}}$ V. The values of ***a***, ***b***, ***c***, and ***d*** are _____ , _____ , _____ , and _____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

30. The damage to biological organisms that X-rays can cause is a result of their

A. high speed
B. small mass
C. short wavelength
D. high radioactivity

Use the following information to answer the next three questions.

In 1997, the Mars Pathfinder Mission included a robotic rover called Sojourner. Sojourner carried a variety of instruments to analyze the Martian soil, rocks, and air.

One of Sojourner's instruments bombarded rocks with alpha particles to produce an "alpha-proton" reaction. One example of an alpha-proton reaction occurs when an alpha particle enters a sodium atom and knocks a proton out of its nucleus. The nuclear reaction equation can be written as follows.

$$^{4}_{2}\text{He} + ^{23}_{11}\text{Na} \rightarrow ^{1}_{1}\text{p} + ^{ab}_{cd}X$$

Scientists on Earth sent instructions to Sojourner via radio waves. Because it took 10 min for the signals to reach the robot, the scientists instructed it to move only a few centimeters at a time.

Numerical Response

11. In the nuclear reaction equation above, the values of a, b, c, and d are _____ , _____ , _____ , and _____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

31. In the nuclear reaction equation above, element X is

A. Al
B. Mg
C. Ne
D. Fe

Numerical Response

12. When the signals were sent to Sojourner, the distance between Earth and Mars, expressed in scientific notation, was $a.b \times 10^{cd}$ m. The values of a, b, c, and d are _____ , _____ , _____ , and _____.

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

32. If the stopping potential of a photocell is $5.60\ \text{V}$, then the maximum kinetic energy of the photoelectrons emitted is

A. $3.50 \times 10^{19}\ \text{J}$

B. $5.60\ \text{J}$

C. $8.96 \times 10^{-19}\ \text{J}$

D. $2.90 \times 10^{-20}\ \text{J}$

33. If a metal with a threshold frequency of $1.1 \times 10^{15}\ \text{Hz}$ is illuminated by light with a wavelength of $1.7 \times 10^{-7}\ \text{m}$, then the maximum kinetic energy of the emitted photoelectrons will be

A. $4.4 \times 10^{-19}\ \text{J}$

B. $7.3 \times 10^{-19}\ \text{J}$

C. $1.2 \times 10^{-18}\ \text{J}$

D. $1.5 \times 10^{-18}\ \text{J}$

Use the following information to answer the next question.

To demonstrate the development of Rutherford's atomic model, a teacher lined up five students at arm's length from each other. She then tossed bean bags toward them. Most of the bean bags went past the line of students without coming into contact with any of them. Occasionally, a bean bag would hit a student and the bean bag would drop to the floor.

34. In this demonstration, the bean bags and the students represent, respectively,

A. alpha particles and electrons

B. electrons and alpha particles

C. nuclei and alpha particles

D. alpha particles and nuclei

---

35. In hydrogen, the radius of the fourth Bohr orbital is

A. 3.31×10^{-12} m

B. 1.32×10^{-11} m

C. 2.12×10^{-10} m

D. 8.46×10^{-10} m

Use the following information to answer the next question.

Observation

The value of q/m for a cathode-ray particle is about 1800 times greater than the value of q/m for a hydrogen ion.

Conclusions That May Be Supported by the Observation

I The charge on a cathode-ray particle is 1800 times greater than the charge on a hydrogen ion.

II The charge on a cathode-ray particle is $\frac{1}{1800}$ of the charge on a hydrogen ion.

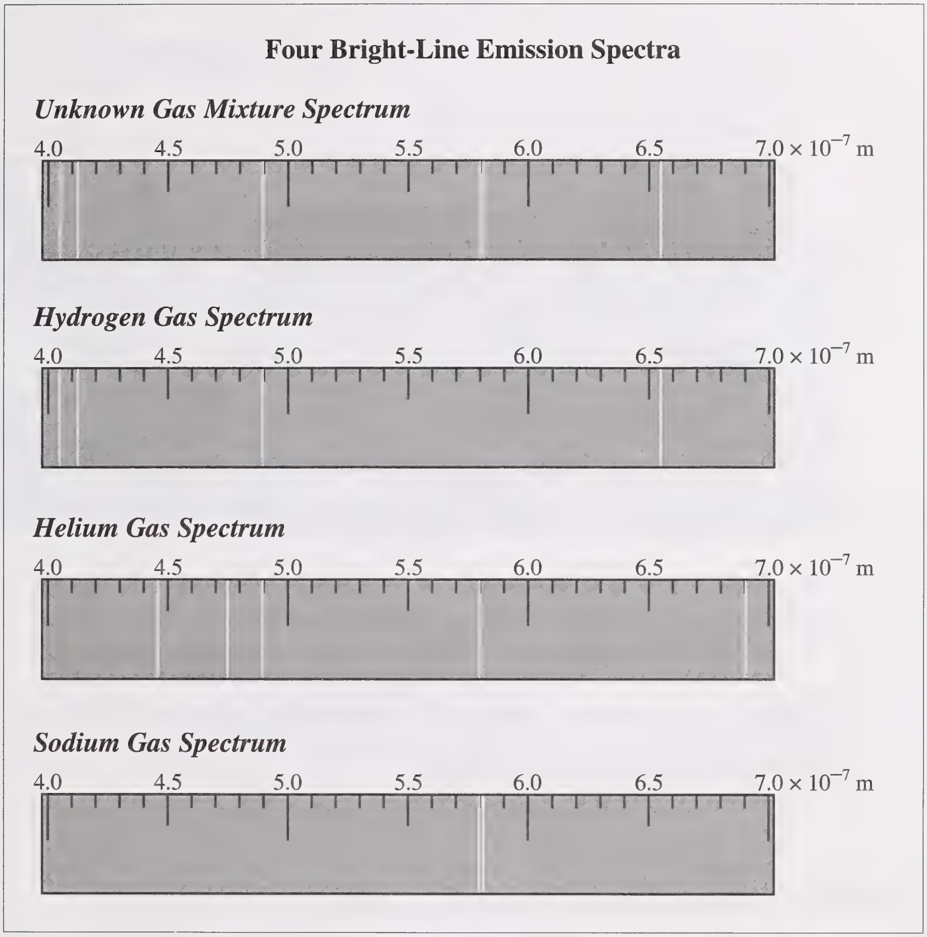
III The mass of a cathode-ray particle is 1800 times greater than the mass of a hydrogen ion.

IV The mass of a cathode-ray particle is $\frac{1}{1800}$ of the mass of a hydrogen ion.

36. The observation supports conclusions

A. I and III
B. I and IV
C. II and III
D. II and IV

Use the following information to answer the next question.



37. According to the spectra above, the unknown gas mixture contains

A. hydrogen, helium, and sodium gases

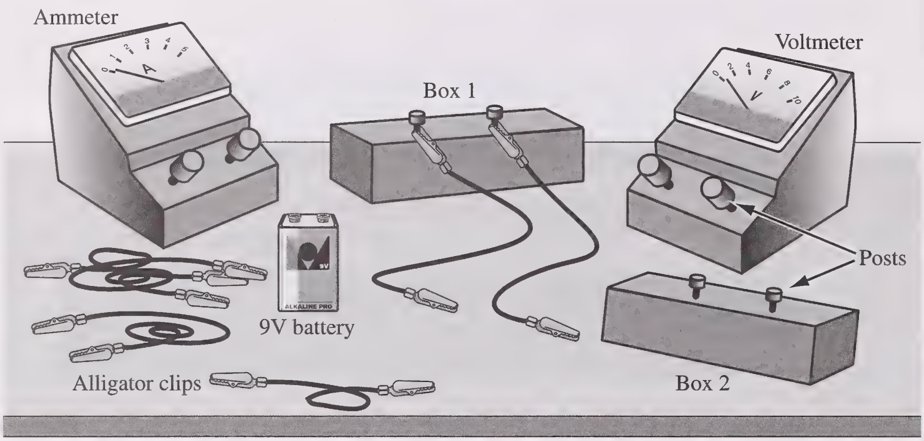
B. hydrogen and sodium gases

C. hydrogen and helium gases

D. helium and sodium gases

Use the following information to answer the next question.

A teacher provides his students with the equipment shown below.



The teacher tells the students that one of the boxes contains two resistors that are placed in parallel and the other box contains two resistors that are placed in series. All four resistors are identical, and the boxes cannot be opened.

Students can connect any pieces of the equipment by attaching alligator clips to their respective posts. They may use some or all of this equipment, but they cannot use any additional equipment.

Written Response—15%

1. Design an experiment that would allow the students to determine which box contains the resistors in series and which box contains the resistors in parallel. Your design should include

- clearly labelled schematic diagrams showing the placement of the individual resistors inside the boxes
- meter placement and measurements
- a description of the analysis that must be done to determine the placement of the resistors in each box

NOTE: Marks will be awarded for the physics used to solve this problem and for the effective communication of your response.

Written-response question 2 begins on the next page.

Use the following information to answer the next question.

Iodine-131 is a radioactive element used in the medical diagnosis and treatment of thyroid problems. Iodine-131 undergoes simultaneous beta and gamma decay and has a half-life of 8.00 days.

Written Response—15%

2.
- Write the complete decay equation for iodine-131.
- Complete the table below by entering the amount of iodine-131 remaining over 40 days.
- Explain how you obtained data for the table.
- Provide a graph of the theoretical decay of 2.00 g of iodine-131.

Time (days)	0	8	16	24	32	40
Mass (g)	2.00					

________________________ (Title)

Use the following additional information to answer the next parts of the question.

The thyroid gland uses iodine to make hormones that the human body needs. The thyroid gland is the only tissue in the human body that collects iodine. An overactive thyroid gland that causes medical problems can be treated with a high dose of iodine-131, which destroys the thyroid gland only.

- A treatment centre receives a shipment of 5.00 g of iodine-131. The treatment centre stores the iodine-131. What is the amount of iodine-131 remaining after 3.00 days?
- Identify at least two risks and one benefit of using radioactive isotopes in medical treatments.

Clearly communicate your understanding of the physics principles that you are using to solve this question. You may communicate this understanding mathematically, graphically, and/or with written statements.

You may continue your answer on the next page.

You have now completed the examination.
If you have time, you may wish to check your answers.

Fold and tear along perforation.

Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
IA	IIA	IIIB	IVB	VB	VIB	VIIB		VIIIB	VIIIB	IB	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA or O
1 H 1.01 hydrogen																	2 He 4.00 helium
3 Li 6.94 lithium	4 Be 9.01 beryllium											5 B 10.81 boron	6 C 12.01 carbon	7 N 14.01 nitrogen	8 O 16.00 oxygen	9 F 19.00 fluorine	10 Ne 20.17 neon
11 Na 22.99 sodium	12 Mg 24.31 magnesium											13 Al 26.98 aluminum	14 Si 28.09 silicon	15 P 30.97 phosphorus	16 S 32.06 sulphur	17 Cl 35.45 chlorine	18 Ar 39.95 argon
19 K 39.10 potassium	20 Ca 40.08 calcium	21 Sc 44.96 scandium	22 Ti 47.90 titanium	23 V 50.94 vanadium	24 Cr 52.00 chromium	25 Mn 54.94 manganese	26 Fe 55.85 iron	27 Co 58.93 cobalt	28 Ni 58.71 nickel	29 Cu 63.55 copper	30 Zn 65.38 zinc	31 Ga 69.72 gallium	32 Ge 72.59 germanium	33 As 74.92 arsenic	34 Se 78.96 selenium	35 Br 79.90 bromine	36 Kr 83.80 krypton
37 Rb 85.47 rubidium	38 Sr 87.62 strontium	39 Y 88.91 yttrium	40 Zr 91.22 zirconium	41 Nb 92.91 niobium	42 Mo 95.94 molybdenum	43 Tc (98.91) technetium	44 Ru 101.07 ruthenium	45 Rh 102.91 rhodium	46 Pd 106.40 palladium	47 Ag 107.87 silver	48 Cd 112.41 cadmium	49 In 114.82 indium	50 Sn 118.69 tin	51 Sb 121.75 antimony	52 Te 127.60 tellurium	53 I 126.90 iodine	54 Xe 131.30 xenon
55 Cs 132.91 cesium	56 Ba 137.33 barium	57-71	72 Hf 178.49 hafnium	73 Ta 180.95 tantalum	74 W 183.85 tungsten	75 Re 186.21 rhenium	76 Os 190.20 osmium	77 Ir 192.22 iridium	78 Pt 195.09 platinum	79 Au 196.97 gold	80 Hg 200.59 mercury	81 Tl 204.37 thallium	82 Pb 207.19 lead	83 Bi 208.98 bismuth	84 Po (208.98) polonium	85 At (209.98) astatine	86 Rn (222.02) radon
87 Fr (223.02) francium	88 Ra (226.03) radium	89-103	104 Unq (266.11) unnilquadium	105 Unp (262.11) unnilpentium	106 Unh (263.12) unnilhexium	107 Uns (262.12) unnilseptium	108 Uno (265) unniloctium	109 Une (266) unnilennium									

57 La 138.91 lanthanum	58 Ce 140.12 cerium	59 Pr 140.91 praseodymium	60 Nd 144.24 neodymium	61 Pm (144.91) promethium	62 Sm 150.35 samarium	63 Eu 151.96 europium	64 Gd 157.25 gadolinium	65 Tb 158.93 terbium	66 Dy 162.50 dysprosium	67 Ho 164.93 holmium	68 Er 167.26 erbium	69 Tm 168.93 thulium	70 Yb 173.04 ytterbium	71 Lu 174.97 lutetium
89 Ac (277.03) actinium	90 Th (232.04) thorium	91 Pa (231.04) protactinium	92 U 238.03 uranium	93 Np (237.05) neptunium	94 Pu (244.06) plutonium	95 Am (243.06) americium	96 Cm (247.07) curium	97 Bk (247.07) berkelium	98 Cf (242.06) californium	99 Es (252.08) einsteinium	100 Fm (257.10) fermium	101 Md (258.10) mendelevium	102 No (259.10) nobelium	103 Lr (260.11) lawrencium

Key

Atomic number →	3
Symbol →	Li
Atomic molar mass →	6.94
Name →	lithium

Based on $^{12}_{6}C$

( ) Indicates mass of the most stable isotope

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PHYSICS DATA SHEET

CONSTANTS

Gravity, Electricity, and Magnetism

Acceleration Due to Gravity **or** Gravitational Field Near Earth	a_g **or** $g = 9.81\ \text{m/s}^2$ **or** $9.81\ \text{N/kg}$
Gravitational Constant	$G = 6.67 \times 10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2$
Mass of Earth	$M_e = 5.98 \times 10^{24}\ \text{kg}$
Radius of Earth	$R_e = 6.37 \times 10^6\ \text{m}$
Coulomb's Law Constant	$k = 8.99 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2$
Electron Volt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$
Elementary Charge	$e = 1.60 \times 10^{-19}\ \text{C}$
Index of Refraction of Air	$n = 1.00$
Speed of Light in Vacuum	$c = 3.00 \times 10^8\ \text{m/s}$

Atomic Physics

Energy of an Electron in the 1st Bohr Orbit of Hydrogen	$E_1 = -2.18 \times 10^{-18}\ \text{J}$ **or** $-13.6\ \text{eV}$
Planck's Constant	$h = 6.63 \times 10^{-34}\ \text{J}\cdot\text{s}$ **or** $4.14 \times 10^{-15}\ \text{eV}\cdot\text{s}$
Radius of 1st Bohr Orbit of Hydrogen	$r_1 = 5.29 \times 10^{-11}\ \text{m}$
Rydberg's Constant for Hydrogen	$R_H = 1.10 \times 10^7\ \frac{1}{\text{m}}$

Particles

	Rest Mass	Charge
Alpha Particle	$m_\alpha = 6.65 \times 10^{-27}\ \text{kg}$	α^{2+}
Electron	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	e^-
Neutron	$m_n = 1.67 \times 10^{-27}\ \text{kg}$	n^0
Proton	$m_p = 1.67 \times 10^{-27}\ \text{kg}$	p^+

Trigonometry and Vectors

$$\sin\theta = \frac{opposite}{hypotenuse}$$

$$\cos\theta = \frac{adjacent}{hypotenuse}$$

$$\tan\theta = \frac{opposite}{adjacent}$$

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$c^2 = a^2 + b^2 - 2ab\cos C$$

For any Vector $\vec{R}$

$$R = \sqrt{R_x^2 + R_y^2}$$

$$\tan\theta = \frac{R_y}{R_x}$$

$$R_x = R\cos\theta$$

$$R_y = R\sin\theta$$

Graphing Calculator Window Format

x: $[x_{\text{min}}, x_{\text{max}}, x_{\text{scl}}]$

y: $[y_{\text{min}}, y_{\text{max}}, y_{\text{scl}}]$

Prefixes Used With SI Units

Prefix	Symbol	Exponential Value	Prefix	Symbol	Exponential Value
pico	p	10^{-12}	tera	T	10^{12}
nano	n	10^{-9}	giga	G	10^{9}
micro	µ	10^{-6}	mega	M	10^{6}
milli	m	10^{-3}	kilo	k	10^{3}
centi	c	10^{-2}	hecto	h	10^{2}
deci	d	10^{-1}	deka	da	10^{1}

Fold and tear along perforation.

EQUATIONS

Kinematics

$\vec{v}_{\text{ave}} = \frac{\vec{d}}{t}$

$\vec{a} = \frac{\vec{v}_{\text{f}} - \vec{v}_{\text{i}}}{t}$

$\vec{d} = \vec{v}_{\text{i}} t + \frac{1}{2}\vec{a}t^2$

$v = \frac{2\pi r}{T}$

$\vec{d} = \vec{v}_{\text{f}} t - \frac{1}{2}\vec{a}t^2$

$\vec{d} = \left(\frac{\vec{v}_{\text{f}} + \vec{v}_{\text{i}}}{2}\right)t$

$v_{\text{f}}^2 = v_{\text{i}}^2 + 2ad$

$a_{\text{c}} = \frac{v^2}{r}$

Dynamics

$\vec{F} = m\vec{a}$

$\vec{F}\Delta t = m\Delta\vec{v}$

$\vec{F}_{\text{g}} = m\vec{g}$

$F_{\text{f}} = \mu F_{\text{N}}$

$\vec{F}_{\text{s}} = -k\vec{x}$

$F_{\text{g}} = \frac{Gm_1 m_2}{r^2}$

$g = \frac{Gm_1}{r^2}$

$F_{\text{c}} = \frac{mv^2}{r}$

$F_{\text{c}} = \frac{4\pi^2 mr}{T^2}$

Momentum and Energy

$\vec{p} = m\vec{v}$

$W = Fd$

$W = \Delta E = Fd\cos\theta$

$P = \frac{W}{t} = \frac{\Delta E}{t}$

$E_{\text{k}} = \frac{1}{2}mv^2$

$E_{\text{p}} = mgh$

$E_{\text{p}} = \frac{1}{2}kx^2$

Waves and Light

$T = 2\pi\sqrt{\frac{m}{k}}$

$T = 2\pi\sqrt{\frac{l}{g}}$

$T = \frac{1}{f}$

$v = f\lambda$

$\frac{\lambda_1}{2} = l; \ \frac{\lambda_1}{4} = l$

$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$

$\lambda = \frac{xd}{nl}$

$\lambda = \frac{d\sin\theta}{n}$

$m = \frac{h_{\text{i}}}{h_0} = \frac{-d_{\text{i}}}{d_0}$

$\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_{\text{i}}}$

Atomic Physics

$hf = E_{\text{k}_{\text{max}}} + W$

$W = hf_0$

$E_{\text{k}_{\text{max}}} = qV_{\text{stop}}$

$E = hf = \frac{hc}{\lambda}$

$\frac{1}{\lambda} = R_{\text{H}}\left(\frac{1}{n_{\text{f}}^2} - \frac{1}{n_{\text{i}}^2}\right)$

$E_n = \frac{1}{n^2}E_1$

$r_n = n^2 r_1$

$N = N_0\left(\frac{1}{2}\right)^n$

Quantum Mechanics and Nuclear Physics

$E = mc^2$

$p = \frac{h}{\lambda}$

$p = \frac{hf}{c}; \ E = pc$

Electricity and Magnetism

$F_{\text{e}} = \frac{kq_1q_2}{r^2}$

$\left|\vec{E}\right| = \frac{kq_1}{r^2}$

$\vec{E} = \frac{\vec{F}_{\text{e}}}{q}$

$\left|\vec{E}\right| = \frac{V}{d}$

$V = \frac{\Delta E}{q}$

$R = R_1 + R_2 + R_3$

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$I_{\text{eff}} = 0.707\ I_{\text{max}}$

$V = IR$

$P = IV$

$I = \frac{q}{t}$

$F_{\text{m}} = IlB_{\perp}$

$F_{\text{m}} = qvB_{\perp}$

$V = lvB_{\perp}$

$\frac{N_{\text{p}}}{N_{\text{s}}} = \frac{V_{\text{p}}}{V_{\text{s}}} = \frac{I_{\text{s}}}{I_{\text{p}}}$

$V_{\text{eff}} = 0.707\ V_{\text{max}}$

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Tear-out Page

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10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210

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Physics 30

January 2002

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Question 1 Marker 1		C1	
Question 1 Marker 2		C2	
Question 1 Marker 3		C3	
Question 2 Marker 1		C4	
Question 2 Marker 2		C5	
Question 2 Marker 3		C6	